

What is claimed is:

1. Fused, crystalline abrasive particle comprising at least 20 percent by volume, based on the total metal oxide volume of said particle, eutectic material,
5 wherein said eutectic material comprises eutectic of at least:

(a) crystalline ZrO_2 and

(b) at least two of:

(i) crystalline Al_2O_3 ,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

2. The fused, crystalline abrasive particle according to claim 1 comprising at least 50 percent by volume, based on the total metal oxide volume of said particle, of said eutectic material.

3. The fused, crystalline abrasive particle according to claim 2 comprising, on a theoretical oxide basis, at least 40 percent by weight Al_2O_3 , based on the total metal oxide content of said particle.

4. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle further comprises primary crystals of Al_2O_3 .

5. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle comprises colonies of said eutectic, and
25 wherein said colonies have an average size of less than 100 micrometers.

6. The fused, crystalline abrasive particle according to claim 5, wherein said colonies have an average size of less than 50 micrometers.

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7. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle comprises colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

5 8. The fused, crystalline abrasive particle according to claim 7, wherein said crystals are, on average, up to 1 micrometer in size.

9. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle further comprises at least one of
10 crystalline rare earth oxide or crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{rare earth oxide}$.

10. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle further comprises at least one of crystalline BaO , CaO , Cr_2O_3 , CoO , Fe_2O_3 , HfO_2 , Li_2O , MgO , MnO , NiO , SiO_2 , TiO_2 ,
15 Na_2O , Sc_2O_3 , SrO , V_2O_3 , ZnO , or complex $\text{Al}_2\text{O}_3 \cdot \text{metal oxide}$ thereof.

11. The fused, crystalline abrasive particle according to claim 3, wherein said fused, crystalline abrasive particle has an average microhardness of at least 13 GPa.

20 ~~Sub E2~~ 12. The fused, crystalline abrasive particle according to claim 3, wherein said complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ further comprises cations in addition to Al and Y.

~~Sub E3~~ 25 13. The fused, crystalline abrasive particle according to claim 3, wherein a portion of said complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ Al cations are substituted with at least one cation selected from the following cations: Cr, Ti, Sc, Fe, Mg, Ca, Si, and Co.

30 14. The fused, crystalline abrasive particle according to claim 3, wherein a portion of said complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ Y cations are substituted with at least one cation selected from the following cations: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Th, Tm, and Yb.

15. The fused, crystalline abrasive particle according to claim 3, wherein a portion of said complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ Y cations are substituted with at least one cation selected from the following cations: Fe, Ti, Mn, V, Cr, Co, Ni, Cu, Mg, Ca, and Sr.

16. The fused, crystalline abrasive particle according to claim 2, said fused, crystalline abrasive particle further comprises primary crystals of $\text{Y}_3\text{Al}_5\text{O}_{12}$.

17. The fused, crystalline abrasive particle according to claim 1, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

18. The fused, crystalline abrasive particle according to claim 17 comprising at least 50 percent by volume, based on the total metal oxide volume of said particle, of said eutectic material.

19. The fused, crystalline abrasive particle according to claim 18 comprising, on a theoretical oxide basis, at least 40 percent by weight Al_2O_3 , based on the total metal oxide content said particle.

20. The fused, crystalline abrasive particle according to claim 19, wherein said fused, crystalline abrasive particle comprises colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

21. The fused, crystalline abrasive particle according to claim 19, wherein said fused, crystalline abrasive particle further comprises at least one of crystalline BaO , CaO , Cr_2O_3 , CoO , Fe_2O_3 , HfO_2 , Li_2O , MgO , MnO , NiO , SiO_2 , TiO_2 , Na_2O , SrO , Sc_2O_3 , V_2O_3 , ZnO , or complex $\text{Al}_2\text{O}_3 \cdot \text{metal oxide}$ thereof.

22. The fused, crystalline abrasive particle according to claim 19, wherein said fused, crystalline abrasive particle has an average microhardness of at least 13 GPa.

5 23. The fused, crystalline abrasive particle according to claim 1, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

10 24. The fused, crystalline abrasive particle according to claim 23 comprising at least 50 percent by volume, based on the total metal oxide volume of said particle, of said eutectic material.

15 25. The fused, crystalline abrasive particle according to claim 24 comprising, on a theoretical oxide basis, at least 40 percent by weight Al_2O_3 , based on the total metal oxide content said particle.

20 26. The fused, crystalline abrasive particle according to claim 25, wherein said fused, crystalline abrasive particle comprises colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

25 27. The fused, crystalline abrasive particle according to claim 25, wherein said fused, crystalline abrasive particle further comprises at least one of crystalline BaO , CaO , Cr_2O_3 , CoO , Fe_2O_3 , HfO_2 , Li_2O , MgO , MnO , NiO , SiO_2 , TiO_2 , Na_2O , SrO , Sc_2O_3 , V_2O_3 , ZnO , or complex $Al_2O_3 \cdot$ metal oxide thereof.

28. The fused, crystalline abrasive particle according to claim 25, wherein said fused, crystalline abrasive particle has an average microhardness of at least 13 GPa.

29. Fused, crystalline abrasive particle comprising at least 20 percent by volume, based on the total metal oxide volume of said particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

- (a) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ and
(b) crystalline ZrO_2 .

30. The fused, crystalline abrasive particle according to claim 29 comprising at least 50 percent by volume, based on the total metal oxide volume of said particle, of said eutectic material.

31. The fused, crystalline abrasive particle according to claim 30 comprising, on a theoretical oxide basis, at least 40 percent by weight Al_2O_3 , based on the total metal oxide content said particle.

32. The fused, crystalline abrasive particle according to claim 30, wherein said fused, crystalline abrasive particle comprises colonies of said eutectic, and wherein crystals making up said colonies are, on average, up to 10 micrometers in size.

33. The fused, crystalline abrasive particle according to claim 30, wherein said fused, crystalline abrasive particle further comprises at least one of crystalline BaO , CaO , Cr_2O_3 , CoO , Fe_2O_3 , HfO_2 , Li_2O , MgO , MnO , NiO , SiO_2 , TiO_2 , Na_2O , SrO , Sc_2O_3 , V_2O_3 , ZnO , or complex $\text{Al}_2\text{O}_3 \cdot \text{metal oxide}$ thereof.

34. The fused, crystalline abrasive particle according to claim 30, wherein said fused, crystalline abrasive particle has an average microhardness of at least 13 GPa.

35. The fused, crystalline abrasive particle according to claim 30 wherein at least a majority by weight of said crystalline ZrO_2 is cubic ZrO_2 .

36. A plurality of particles having a particle size distribution ranging from fine to coarse, wherein at least a portion of said plurality of particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline ZrO_2 and

(b) at least two of:

(i) crystalline Al_2O_3 ,

(ii) first crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$, or

(iii) second, different, crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

37. The plurality of particles according to claim 36, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

38. The plurality of particles according to claim 36, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$, and (c) second, different, crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

39. A plurality of particles having a particle size distribution ranging from fine to coarse, wherein at least a portion of said plurality of particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ and

(b) crystalline ZrO_2 .

40. The plurality of particles according to claim 39 wherein at least a majority by weight of said crystalline ZrO_2 is cubic ZrO_2 .

41. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline ZrO_2 and

(b) at least two of:

(i) crystalline Al_2O_3 ,

(ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or

(iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

42. The plurality of abrasive particles according to claim 41, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

43. The plurality of abrasive particles according to claim 41, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

44. A plurality of abrasive particles having a specified nominal grade, said plurality of abrasive particle having a particle size distribution ranging from fine to coarse, wherein at least a portion of said abrasive particles is a plurality of fused, crystalline abrasive particles, said fused abrasive particles comprising at least 20 percent by volume, based on the total metal oxide volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and

(b) crystalline ZrO_2 .

45. The plurality of abrasive particles according to claim 44 wherein at least a majority by weight of said crystalline ZrO_2 is cubic ZrO_2 .

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46. A method for making fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline ZrO_2 and (b) at least two of (i) crystalline Al_2O_3 , (ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or (iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$, said method comprising:

melting at least one Al_2O_3 source, at least one Y_2O_3 source, and at least one ZrO_2 source to provide a melt; and

converting the melt to said fused, crystalline abrasive particles.

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The method according to claim 38, wherein converting includes:

cooling the melt to provide a solidified material; and
crushing the solidified material to provide said fused, crystalline abrasive particles.

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The method according to claim 47, wherein cooling the melt includes cooling the melt with metallic plates.

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The method according to claim 47, wherein cooling the melt includes cooling the melt with metallic balls.

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The method according to claim 46, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 (b) crystalline Al_2O_3 , and crystalline complex $Al_2O_3 \cdot Y_2O_3$.

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The method according to claim 46, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

52. A method for making fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least (a) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ and (b) crystalline ZrO_2 , said method comprising:
5 melting at least one Al_2O_3 source, at least one Y_2O_3 source, and at least one ZrO_2 source to provide a melt; and
converting the melt to said fused, crystalline abrasive particles.

53. An abrasive article comprising a binder and a plurality of
10 abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

(a) crystalline ZrO_2 and

(b) at least two of:

(i) crystalline Al_2O_3 ,

(ii) first crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$, or

(iii) second, different, crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

54. The abrasive article according to claim 53, wherein said article is a coated abrasive article, and further comprises a backing.

55. The abrasive article according to claim 53, wherein said article is a bonded abrasive article.

56. The abrasive article according to claim 53, wherein said article is a nonwoven abrasive article, and further comprises a nonwoven web.

57. The abrasive article according to claim 53, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

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58. The abrasive article according to claim 53, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$, and (c) second, different, crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

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59. An abrasive article comprising a binder and a plurality of abrasive particles, wherein at least a portion of said abrasive particles are fused, crystalline abrasive particles comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material
10 comprises eutectic of at least:

- (a) crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$ and
- (b) crystalline ZrO_2 .

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60. The abrasive article according to claim 59 wherein at least a
15 majority by weight of said crystalline ZrO_2 is cubic ZrO_2 .

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61. A vitrified bonded abrasive article comprising a plurality of abrasive particles bonded together via vitrified bonding material, wherein at least a portion of said plurality of abrasive particles are fused, crystalline abrasive particles
20 comprising at least 20 percent by volume, based on the total volume of the respective particle, eutectic material, wherein said eutectic material comprises eutectic of at least:

- (a) crystalline ZrO_2 and
- (b) at least two of:
 - (i) crystalline Al_2O_3 ,
 - (ii) first crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$, or
 - (iii) second, different, crystalline complex $\text{Al}_2\text{O}_3 \cdot \text{Y}_2\text{O}_3$.

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62. The vitrified bonded abrasive article according to claim 61,
30 wherein said vitrified bonding material comprises silica, alumina, and boria.

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63. The vitrified bonded abrasive article according to claim 62,
wherein said vitrified bonding material comprises at least 10 percent by weight of said alumina.

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64. The vitrified bonded abrasive article according to claim 63,
wherein said vitrified bonding material comprises at least 10 percent by weight of said boria.

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65. The vitrified bonded abrasive article according to claim 61,
wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 ,
and (c) crystalline complex $Al_2O_3 \cdot Y_2O_3$.

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66. The vitrified bonded abrasive article according to claim 61,
wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline
complex $Al_2O_3 \cdot Y_2O_3$, and (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

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67. A vitrified bonded abrasive article comprising a plurality of
abrasive particles bonded together via vitrified bonding material, wherein at least a
portion of said plurality of abrasive particles are fused, crystalline abrasive particles
comprising at least 20 percent by volume, based on the total volume of the respective
particle, eutectic material, wherein said eutectic material comprises eutectic of at least:
(a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and
(b) crystalline ZrO_2 .

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68. The vitrified bonded abrasive article according to claim 67,
wherein at least a majority by weight of said crystalline ZrO_2 is cubic ZrO_2 .

30 Sub E3 58
69. A method of abrading a surface, said method comprising:
contacting at least one fused, crystalline abrasive particle
comprising at least 20 percent by volume, based on the total volume of the respective
particle, eutectic material, wherein said eutectic material comprises eutectic of at least

(a) crystalline ZrO_2 and (b) at least two of (i) crystalline Al_2O_3 , (ii) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, or (iii) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$, with a surface of a workpiece; and

5 moving at least of one said fused abrasive particle or said surface relative to the other to abrade at least a portion of said surface with said fused abrasive particle.

~~61~~
~~70.~~ The method according to claim ~~69~~⁶⁰, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline
10 complex $Al_2O_3 \cdot Y_2O_3$.

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~~71.~~ The method according to claim ~~69~~⁶⁰, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) first crystalline complex $Al_2O_3 \cdot Y_2O_3$, and
15 (c) second, different, crystalline complex $Al_2O_3 \cdot Y_2O_3$.

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~~72.~~ A method of abrading a surface, said method comprising:
contacting at least one fused, crystalline abrasive particle
comprising at least 20 percent by volume, based on the total volume of the respective
particle, eutectic material, wherein said eutectic material comprises eutectic of at least
20 (a) crystalline complex $Al_2O_3 \cdot Y_2O_3$ and (b) crystalline ZrO_2 , with a surface of a
workpiece; and
moving at least of one said fused abrasive particle or said surface
relative to the other to abrade at least a portion of said surface with said fused abrasive
particle.

~~64~~
~~73.~~ The method according to claim ~~72~~⁶³, wherein said eutectic is eutectic of at least (a) crystalline ZrO_2 , (b) crystalline Al_2O_3 , and (c) crystalline
25 complex $Al_2O_3 \cdot Y_2O_3$.

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